INTEGRATION AND IMMERSIVE PRESENTATION OF VARIOUS HEAD INFORMATION

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Abstract - **This paper describes the measurement of various head images and the presentation of integrated images on an immersive projection system (IPS). We handled optical and magnetic method to obtain the information about face, head, brain and blood vessel. The system enables to observe the inside of a head interactively using a joystick, which gives the impression to travel in a human head freely. It is thought that the integrated images are available not only for diagnosis but also treatment of a brain in the future robot surgical operation with a manipulator or a micro-machining device.**
Keywords - ***immersive projection system, MRI, interactivity,***

I. INTRODUCTION

The progress of medical imaging provides us many kinds of human information, morphology, function, metabolism and so on, with various medical equipments [1]. For example, anatomy of a human head can be revealed with magnetic resonance imaging (MRI), structure of brain blood vessels with magnetic resonance angiography (MRA) and brain metabolism with positron emission tomography (PET). Each medical image had been presented respectively, but high computer performance enables to integrate various medical images with matching their coordinate systems [2].

Ten years ago or more, such kinds of information were presented as a two-dimensional (2D) image and a medical doctor was forced to guess the three-dimensional (3D) structure of an organ, a tissue and so on. The recent development of computer graphics (CG)[3] resulted in reconstructing a 3D image from many 2D images. As a 3D image can be observed from any direction, a 3D medical image is effective to educate a medical student and very useful for diagnose and the plan before a surgery [4].

Virtual reality (VR)[5] and CG technique realize the fantastic world that we have never experimented. However, the presentation of a 3D image on a cathode ray display (CRT) does not give immersive feeling to us. Nowadays, the immersive projection system (IPS) has been developed using some large screens [6], which presents us the feeling as if we were in a human body [7]. Here, we obtained various kinds of information about a head, integrated them and projected on a CRT or an IPS. This document reports the measurement method, the reconstructing process and the presentation of the results on a CRT or an IPS.

II. METHOD

A. Face Shape

We measured head shape using a range finder (Cyberware: Head & Face 3D Scanner) [8]. On measurement, a subject sat on the chair that rotated at the constant angular velocity and the distance between face surface and rotation axis was measured. Simultaneously, a texture image of a face was captured. The range finder acquires the face shape and texture 512 times in a rotation and in each acquisition the measurements were performed at 450 points on a line in the pitch of 0.7mm. Fig.1 shows range data, the texture image of a face and the patched texture image on range data.

(a) (b) (c)
Fig.1 Face shape image (a) range data (b) texture image (c) mixed result

B. Brain Morphology

A head shape and a brain surface were obtained from MRI slices measured with an MRI scanner (Siemens: 1.5T MR scanner) [9]. As imaging sequence, we chose gradient echo method combining fast imaging method (FLASH: fast low angle shot) with the flip angle of 8deg, time of repetition T_r of 11.6msec and time of echo T_e of 4.9msec [10]. Table I summaries the parameters of MRI slices and Fig.2 shows an example image of MRI slices.

TABLE I
PARAMETERS OF MRI SLICES

Image Size	512 x 512pixel
Image Resolution	0.5 x 0.5mm/pixel
Slice Thickness	0.5mm
Image Depth	12bits
Slice Number	256

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
25 Oct 2001	N/A	-

Title and Subtitle Integration and Immersive Presentation of Various Head Information	**Contract Number**
	Grant Number
	Program Element Number
Author(s)	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) Nara Institute of Science and Technology Ikoma, Japan	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es) US Army Research, Development & Standardization Group (UK) PSC 802 Box 15 FPO AE 09499-1500	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)
Distribution/Availability Statement Approved for public release, distribution unlimited	
Supplementary Notes Papers from 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, October 25-28, 2001, held in Istanbul, Turkey. See also ADM001351 for entire conference on cd-rom., The original document contains color images.	
Abstract	
Subject Terms	
Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU
Number of Pages 4	

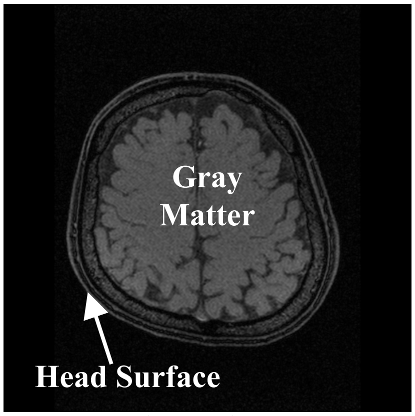


Fig.2 MRI image

A head shape image was reconstructed with extracting the head surface edge. While a brain surface image was done with the method described below. Fig.3 is a histogram of an MRI image. On the histogram, a peak appears in relative high gray level marked by ‘A’, which corresponds to gray matter. Therefore, the threshold value was set at the minimum value marked by ‘B’ [11]. After binarization, dilation, erosion and labeling procedure were performed, the labeled regions with larger area were selected as gray matter as shown Fig.4 and the outline of gray matter was extracted. These procedures were applied to all MRI slices and a 3D brain surface image was reconstructed.

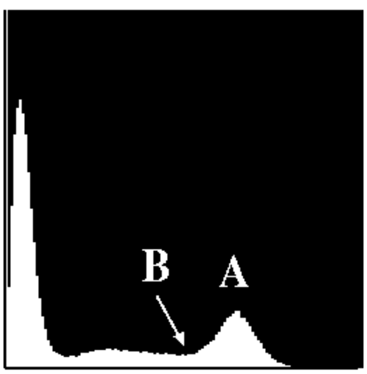


Fig.3 Histogram of MRI image

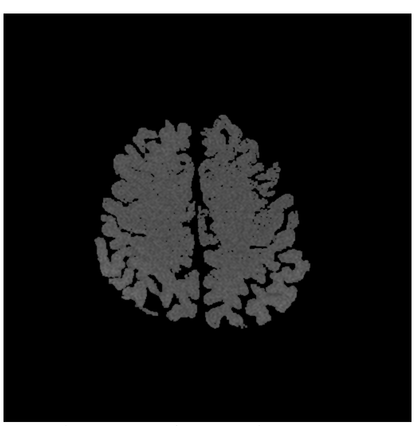


Fig.4 Image of extracted gray matter

C. Brain Blood Vessel

A 3D brain blood vessel image was reconstructed from MRA slices obtained with 3D-TOF (time of flight) based on gradient echo method [10]. Table II summaries the parameters of MRA slices and Fig.5 shows an example image of MRA slices.

TABLE II
PARAMETERS OF MRA SLICE

Image Size	512 x 512pixel
Image Resolution	0.5 x 0.5mm/pixel
Slice Thickness	0.5mm
Image Depth	12bits
Slice Number	228

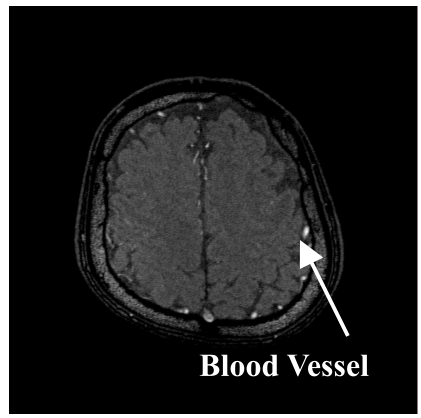


Fig.5 MRA image

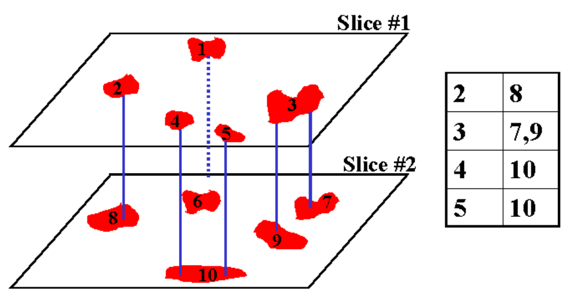


Fig.6 Examination of connectivity

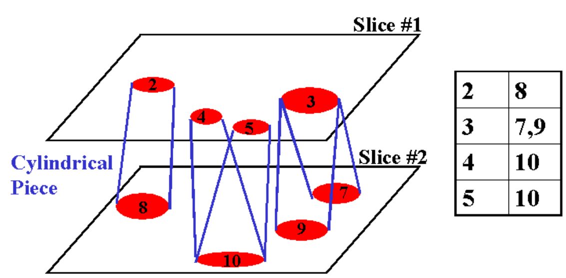


Fig.7 Painting of blood vessel s

On MRA images, blood vessels were represented as brighter spots shown in Fig.5. The slice or the distance from the brain midline, however, varied the gray level of blood vessels. Therefore, the threshold value was determined for each slice [7] and labeling procedure followed.

Then, connectivity was examined between adjacent slices as shown in Fig.6, where the labeled regions were supposed to be connected each other whether only one pixel was overlapped between the slices. The area and gravity were calculated for the labeled regions and blood vessels were painted in a hexagon shape as shown in Fig.7. These procedures were applied to all MRA slices and a 3D blood vessel image was reconstructed.

III. Presentation

A. Presentation on a CRT

As described in the last section, we reconstructed several images of a head. Fig.8 shows these images presented on a CRT sequentially. The matching of coordinate systems between face and head shape was performed manually. No matching was carried out between head shape and brain surface and between brain surface and blood vessel. Fig.8 demonstrates smooth morphing from face to brain vessel and various kinds of head information could be observed from many viewpoints.

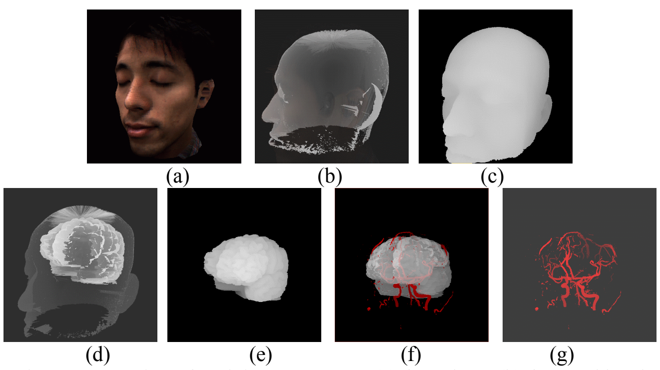


Fig.8 Presentation of each image on CRT (a) face shape (b) face and head shape (c) head shape (d) head shape and brain surface (e) brain surface (f) brain surface and blood vessel (g) blood vessel

B. Presentation on an IPS

After extracting gray matter, 256 slices of 512 x 512pixel was converted to 512 x 512 x 512voxel using linear interpolation. Three surfaces of 80 x 80 x 60voxel data among the original voxel data were drawn on three screens transparently so that blood vessels can be seen through MRI images.

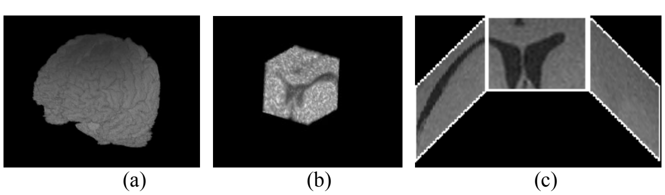


Fig.9 Projection of MRI images (a) 512 x 512 x 512voxel (b) 80 x 80 x 60voxel (c) projection on three screens

A head shape, a brain vessel and MRI images were projected on an IPS. Fig.10 shows the IPS that has four screens with the size of 3 x 2.3m. On this presentation, these images were projected on center, left and right screen only. This system possesses a pointing device, a joystick as seen in Fig.9, which was used to move a viewpoint and direction interactively.

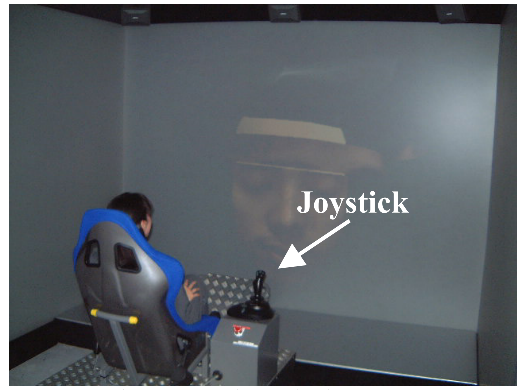


Fig.10 Immersive projection system

Fig.11 shows the presentation of 3D head shape on an IPS just before going into a head. Fig.12 shows blood vessels and MRI images. Some vessels could be seen through MRI images.

Fig.11 3D image of head shape projected on an IPS

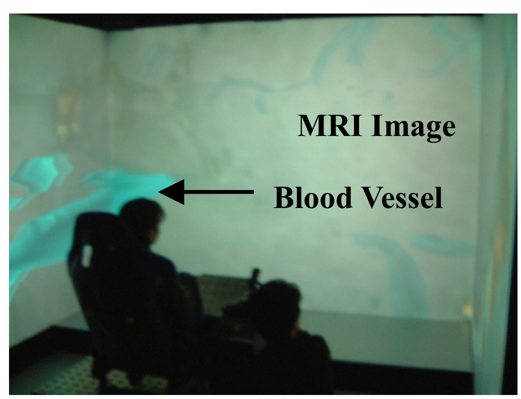
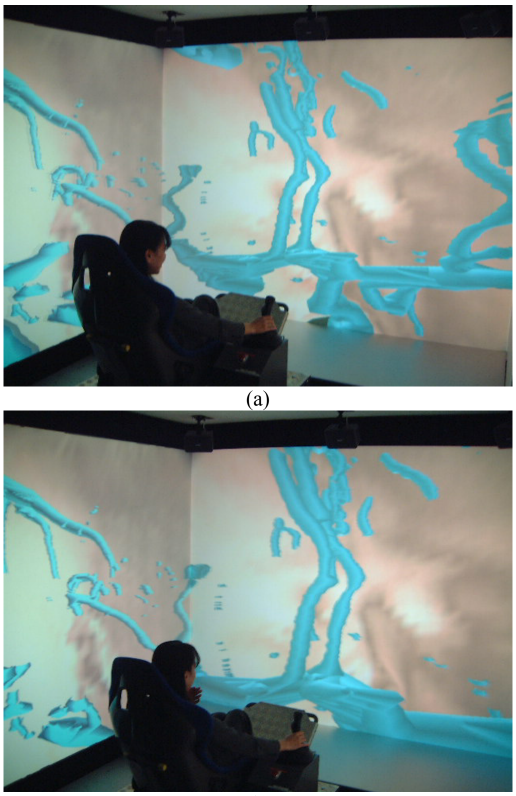


Fig.12 3D image of MRI and blood vessel projected on an

Fig.13 shows 3D head shape and brain vessels with the eye position set in the head. These images do not involve MRI images and another side of the head surface can be observed. Fig.13 also indicates interactive observation of the 3D image using a joystick. It is easy to change viewpoint and viewing direction because the change was performed using a joystick that is one of the most comfortable pointing devices. Moreover, this system provided us the walk through in a human head and guided us to go into and out of a head freely.



(a)

(b)

Fig.13 Interactive observation (a) seeing head shape and blood vessel (b) moving viewpoint slightly upward

IV. Conclusion

We obtained various kinds of head information with the optical and magnetic method and projected the reconstructed images on a CRT or an IPS. The IPS has the function of interactive observation, which makes the spatial relationship among tissues clear. Furthermore, this system gives us the immersive environment that we are staying in a human body. Therefore, the system is thought to be useful for a catheter surgery as monitoring system [12]. In the future, this system will be the essential tool for robot surgery with a manipulator [13] and an ongoing micro-machining device [14].

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